White Pine and White Oak Lumber in Roebling's Four D&H Aqueducts

By S. Robert Powell, Ph.D.

The four aqueducts that Johann Roebling designed and built for the D&H (Lackawaxen, Delaware, Neversink, High Falls) were major components of the D&H transportation system between the coal fields of northeastern Pennsylvania and the Hudson River (see our four articles on those aqueducts in the *Bulletin*: 9/2019; 11/2019; 12/2019; 1/2020).

Those four aqueducts, which were unqualified successes, both as structures and as features of a complex transportation system, were primary components of the third enlargement of the D&H Canal, which was begun in 1848 and completed in 1849-1850. (The Lackawaxen and Delaware aqueducts were built in 1847-1848, and were put in service on April 26, 1849; the Neversink and High Falls aqueducts, which were built by the D&H in 1828-1829 when the Canal was constructed, were re-built in 1849-1850 by Roebling, and were put in service in 1851.)

With the third enlargement completed, the D&H Canal was now 48-50 feet wide at the water line, 32 feet wide at the bottom, and 6 feet deep, and boats with a capacity of 130 tons, which could be taken directly into the Hudson River at Rondout and towed down to New York, could now be used. Fifty-seven of the locks were enlarged to 100 feet by 15 feet, and the annual capacity of the canal was now one million tons per year (five times what it was in 1842).

In Roebling's construction contract from the D&H for the four bridges, it was stated that Roebling would construct the superstructure or suspended spans, including all iron, timber, and wire work, and that the D&H would do all masonry and cement work.

Much has been written about Roebling's designs for these four remarkable bridges, and about the cables* that support them, but very little has been written about the stones and the wood used in their construction. In our articles in the *Bulletin* in the December 2019 and January 2020 issues, we focused on the stones used in these aqueducts. We will now take a close look at the lumber used, above and below ground, in their construction.

In the Roebling archive at Rensselaer Polytechnic Institute, there is a flyer, shown here, titled "LUMBER / Wanted on the Del. & Hudson Canal," dated February 23, 1847, that was issued by "John A. Roebling, Engineer." From that flyer, we have learned a great deal about the lumber used, above ground, in constructing the Lackawaxen and Delaware Aqueducts (and, by extension, the Neversink and High Falls Aqueducts).

To build the Lackawaxen and Delaware Aqueducts, Roebling, by means of this flyer, made it known that he wanted to purchase 442,558 feet board measure of "good sound White Pine, all work full size, free of shakes, rents or black knots, when counter-hewed."

What are some of the qualities of white pine that made it Roebling's wood of choice for the aqueducts? White pine, first of all, has a straight an even grain, and is both light and strong, and white pines usually grow to heights of 80 feet or more (the white pine is called by some the "Sequoia of the Northeast" because it grows to such majestic heights), with diameters as much as three feet. As such, white pine would have met the quality and size requirements of the lumber

required by Roebling. White pines, second of all, were abundant, then as now, in the areas where the aqueducts were to be built.

Note in the specifications shown in this lumber poster (and in the two details shown here from that poster) the enormous size and quantity specifications that Roebling established for some of the lumber to be used in building these two aqueducts: 390 pieces, 16 by 6 ½ inches, and 31 feet long; plank, 25 or 26 feet long, 2 ½ inches *uniformly* thick, 76,680 feet board measure; plank, 14 feet 4 inches long, 2 ½ inches uniformly thick, 76,680 feet board measure; 400 pieces, 14 by 7 inches at one end, 7 by 7 at the other, 16 feet long. (Given the fact that a 2 x 4 x 8, at the present time costs about $6, it's interesting to think what Roebling's lumber order—four hundred and forty-two thousand five hundred and fifty eight feet of lumber, much of it of very unusual lengths and thicknesses--would cost at today's prices for lumber.)

The enormous quantity of white pine lumber that Roebling wanted to buy for these two aqueducts was to be "delivered on the Pennsylvania side of the Delaware river above high water mark, between the mouth of the Lackawaxen and Delaware Dam (for Del. and Hud. Canal) by or before the first day of July next [1848]. Payment will be made when the Lumber is delivered on the bank as above stated, and approved and accepted to the satisfaction of the Engineer on Delaware and Hudson Canal for the time being. Proposals are desired to be in writing, stating the price per one thousand feet board measure, and directed to the subscriber, at the office of the Delaware and Hudson Canal Company, in Honesdale, Wayne county, Pa."

How was that lumber used by Roebling in building the Lackawaxen and Delaware Aqueducts? (Similar lumber requests were surely issued by Roebling when he built the Neversink and High Falls aqueducts in 1849-1850.) In Robert W. Vogel's "Roebling's Delaware and Hudson Canal Aqueducts," 1971, pp. 11, 15) we read: "The aqueducts were designed, like the locks, to pass only a single boat, but nevertheless had a [towing] path on each side. Closely following the design used by Roebling at Pittsburgh, these aqueducts had a heavy wood trunk or flume holding between 6 and 6 ½ feet of water, 19 feet wide at the waterline. The trunk sides were built up of two thicknesses of 2 ½ inch, untreated, white-pine plank, laid tight on opposite diagonals and caulked up to the waterline, in effect forming a rigid, solid-lattice truss, but without functional top and bottom chords. The stiffness of these great trusses was such that they were capable of sustaining their own deadweight, leaving the cables to carry only the water load. The floor was also of double plank, carried by transverse double floor beams, in turn hung from the suspenders as in a conventional suspension bridge. The 8-foot towpaths were bracketed out from the sides, level with the trunk top."

White pine lumber, then, was used extensively above ground by Roebling in the four suspension aqueducts. Below ground, on all four aqueducts, Roebling's design for the bridges called for the use of another kind of lumber, white oak. In the cable anchoring system that was designed and patented by Roebling (patent approved August 26, 1846), white oak lumber was of great importance.

In his patent application for a new mode of anchorage applicable to wire bridges as well as chain bridges, Roebling states: "My improvement consists of a new mode of anchorage, applicable to Wire Bridges as well as Chain Bridges. In place of resting the anchor plate directly against a stone

wall I apply in my mode a system of timbers, [emphasis added] which serve in a manner as a foundation for the superincumbent masonry, distribute the great pressure of the foundation plates over a large surface of masonry, reduce therefore its length or depth, and by its yielding and elastic nature, prevent the breaking of the anchor plates. [emphasis added]. The bed plate [a 6-foot square cast iron plate] to which the last link [of the anchor chain] is attached is laid in a thick bed of hydraulic cement. On top of the anchor plate a platform is laid down, of about 10 feet square and 8 inches thick, composed of 4 courses of two inch white oak plank, [emphasis added] the courses crossing each other at right angles, and all spiked together with iron spikes. A thin layer of cement is spread over the anchor plate before the plank is laid down… The platform being well settled down, leveled and covered with cement, a course of timbers is laid down next which extends to the abutment. It is as wide as the platform and composed of white oak sticks hewed 12 inches square and of even thickness. The two courses, which are opposite each other, serve for the support of the resisting walls which support the pressure of the curved chains and also for the support of the main courses of foundation timbers. This course is composed of about 13 white oak sticks, 12 to 15 inches thick, 40 feet long and extending all the way across the pit. It serves for the support of the masonry the weight of which is to resist the pressure of the anchor plate. This body of masonry being about 40 feet long and 12 feet wide need not be very deep to offer a sufficient resistance to the pressure of the anchor plate. All of the timbers are copiously grouted with thin lime mortar for the purpose of preservation. They will never rot as they are deeply buried with ground and entirely excluded from the air."

In summation, Roebling states: "What I claim as my original invention and wish to secure by Letters Patent is: The application of a timber foundation, in place of stone, in connection with anchor plates, to support the pressure of the anchor chains or cables against the anchor Masonry of a Suspension Bridge--for the purpose of increasing the base of that masonry, to increase the surface opposed to pressure, and to substitute wood as an elastic material in place of stone [emphasis added] for the bedding of anchor plates--the timber foundation either to occupy either an inclined position, where the anchor cables or chains are continued in a straight line below ground, or to be placed horizontally where the anchor cables are curved."

White pine and white oak lumber, therefore, were of great importance in the construction of the four aqueducts that Roebling built for the Delaware and Hudson Canal Company in the period 1846-1850. One of those remarkable bridges, the Delaware Aqueduct, is still in use today, as a motor vehicle bridge, 172 years after it was built.

*The length and the diameter of the cables on a suspension bridge, it is interesting to note, are a function of the ambient temperature, year around, of the location where the bridge is located. In warm weather, the cables are slightly longer and thicker than they are in the winter. These seasonal variations in the diameter and length of the cables are managed in the Roebling D&H aqueducts by (1) the cast iron cable saddles at the top of the piers, which are just wide enough for the cables in warm weather, and (2) by the system of white oak timbers above the anchor plate in all four of the aqueducts, which is elastic enough to make possible the slight increase in the length of the cables in the summer. Were those seasonal variations in the diameter and length of the cables not possible, the support systems for the cables could be compromised, causing the bridge to collapse.

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LUMBER

WANTED, on THE DEL. & HUDSON CANAL.

PROPOSITIONS

Will be received until the 10th day of March next, for furnishing and delivering the following bill of Lumber, viz:

390	Pieces,	16 by 6 1-2 inches,—31 feet long,	104,910	feet Board Measure,	1,600	feet Linial Measure, 6 by 6 inches, for Railing,	4,800 feet Board Measure.
400	do.	14 by 7 inches at one end, 7 by 7 at the other,—16 ft. long,	39,200	do.	1,400	do. 6 by 7, any length over 20 feet,	4,900 do.
200	do.	7 by 18,—20 feet long,	30,400	do.	1,400	do. 5 by 5, do.	1,450 do.
800	do.	2 1-2 by 10,—10 feet long,	16,800	do.	Plank, 25 or 26 feet long, 2 1-2 inches *uniformly* thick,		76,680 do.
800	do.	2 by 10,—7 feet 8 inches long,	10,200	do.	Plank, 14 feet 4 inches long, 2 1-2 inches *uniformly* thick,		76,680 do.
400	do.	7 by 7,—12 feet long,	19,600	do.	Joice, 2 in. by 10, or 2 inches by 12, either 16, 20, or 24 ft. long,		22,400 do.
400	do.	6 by 7,—6 feet 8 inches long,	8,800	do.	Joice, 1 1-2 by 10 inches, 16 or 24 feet long,		19,200 do.
1,600	feet Linial Measure, 7 by 7 inches, for Railing,		6,533	do.			
					Total Board Measure of Pine,		442,553 feet.

All the above bill to be of good sound White Pine, and work full size, free of shakes, rents or black knots, when counter-hewed, and delivered on the Pennsylvania side of the Delaware river above high water mark, between the mouth of the Lackawaxen and Delaware Dam (for Del. and Hud. Canal) by or before the first day of July next. Payment will be made when the Lumber is delivered on the bank as above stated, and approved and accepted to the satisfaction of the Engineer on Delaware and Hudson Canal for the time being. Proposals are desired to be in writing, stating the price per one thousand feet board measure, and directed to the subscriber, at the office of the Delaware and Hudson Canal Company, in Honesdale, Wayne county, Pa. For any information relating to the above bill of Lumber, apply to the Engineers or Superintendents on Delaware and Hudson Canal.

JOHN A. ROEBLING, *Engineer.*

February 23d, 1847.